

***Does Sample Size Matter?: The Implications of Altering Sample Size When  
Thickening Infant Formula with Oatmeal Cereal and What it Means for  
Speech-Language Pathologists Who Treat Dysphagia in the Neonatal  
Intensive Care Unit***

**An Honors Thesis (HONR 499)**

**by**

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## Abstract

In the Neonatal Intensive Care Unit (NICU), speech-language pathologists (SLPs) help treat infants who have swallowing disorders, also known as dysphagia (American Speech-Language Hearing Association, n.d.). One common thickener used to assist infants during feedings is oatmeal cereal (Madhoun, Siler-Wurst, Sitaram, & Jadcheria, 2015; Eney, 2015). As infants in the NICU gradually progress with their ability to swallow more amounts of formula without aspiration, SLPs often keep the ratio of oatmeal per ounce (oz.) of formula equivalent as the amount of liquid per feeding session is increased (Madhoun, Siler-Wurst, Sitaram, & Jadcheria, 2015). This is done because it is thought that the thickness would be the same as prior feedings even though it is a larger amount. The following is an investigation of whether this practice is effective and if the same thickness level is truly maintained when altering the amount of liquid with the same ratio of oatmeal per fluid ounce. This concept was tested by measuring the viscosities of four different infant formula-oatmeal cereal mixtures each having 2 tablespoons (Tbsp.) of oatmeal per 1 oz. of liquid. These mixtures were 0.5 Tbsp. of oatmeal cereal mixed in 1 oz. of formula, 1 Tbsp. in 2 oz., 2 Tbsp. in 4 oz., 4 Tbsp. in 8 oz., and 8 Tbsp. in 16 oz. The viscosities were measured via a viscometer (Table 3; Graph 1) using the National Dysphagia Diet (Table 1) and the International Diet Standardisation Initiative flow test (Table 2) to determine the thickness level.

## **Acknowledgments**

First off, I would like to thank my family. My parents, brother, and sister have been a great support system during my undergraduate education at Ball State University.

Secondly, I want to thank my thesis advisor, Mary Ewing, for being a great resource. As a Board Certified Swallowing Specialist (BCS-S), she has provided me with knowledgeable information about the treatment of pediatric dysphagia.

Lastly, I want to extend my deepest gratitude to speech-language pathologists and Ball State University partners, Molly Jones and Catherine "Cassie" Seitz. I want to thank Cassie for providing me with the idea of testing sample sizes. I want to thank Molly for coming to the physics/viscosity lab on her days off to assist me with testing the viscosities of the addressed liquids.

### **Process Analysis Statement**

When selecting a topic for my Honors thesis, I wanted it to be applicable for speech-language pathologists practicing in the field of pediatric dysphagia. This semester, I am taking a physics course titled "Analysis of Fluid Viscosities Used to Treat Human Dysphagia." This course includes collaboration between speech-language pathologists and students. The community partners of this course are speech-language pathologists Catherine Seitz of Indiana University Health Ball Memorial Hospital and Molly Jones of St. Vincent Healthcare Systems. Earlier during this semester, I asked them for input on a topic that they would like to see tested for my thesis. Seitz suggested testing to see whether altering sample sizes while maintaining the same amount of oatmeal cereal per fluid ounce (oz.) of infant formula changed the viscosity of the infant formula.

I decided to test a control ratio of an oatmeal-formula mixture and test different sample sizes maintaining the same ratio. The control I used involved Gerber oatmeal cereal and Gerber infant formula. Gerber oatmeal cereal was selected as the brand of oatmeal cereal because it was the type of oatmeal cereal that was used by the community partners. I chose Gerber Soothe infant formula because it is one of Gerber's formulas that can be mixed with Gerber oatmeal cereal. The control sample size and ratio was based upon Gerber's recipe of placing 1 Tbsp. of cereal in 4 to 5 Tbsp. of formula (2 to 2.5 oz.) (Gerber Products Company, 2015). The continuous ratio of using 1 Tbsp. of oatmeal cereal per 2 oz. of liquid was investigated. I decided to alter the control by reducing and increasing the sample sizes by two-fold. This allowed the ratio of 1 Tbsp. per 2 oz. to be maintained easily. The sample sizes investigated were 0.5 Tbsp. per 1 oz., 1 Tbsp. per 2 oz. (control), 2 Tbsp. per 4 oz., 4 Tbsp. per 8 oz., and 8 Tbsp. per 16 oz.



The selection of the spindle used for the viscometer was one of the challenging components of the experiment. The amount of liquid poured into the small sample size adapter placed under the viscometer is dependent upon the spindle size selected. To use spindle #18, one needs to put 6.7 milliliters (mL) in the sample size adapter. If spindle #28 is used, one puts 11 mL into the viscometer's sample size adapter. Lastly, if spindle #25Z is used, 16.1 mL of liquid must be placed inside the sample size adapter (AMETEK Brookfield, 2017). Spindle size #28 was initially used to measure the viscosity of the first test, which tested the viscosity of the liquid mixture of 1 Tbsp. of oatmeal per 2 oz. of formula. Because slightly thick liquids are most often used to feed infants (International Dysphagia Diet Standardisation Initiative, 2017) and larger spindles are more commonly used to measure thinner sample sizes, spindle #28 was selected. However, the torque of the spindle was low, in between 11 and 12%. The closer the torque is to 100%, the more specific viscosity readings are (AMETEK Brookfield Engineering, 2017). Assuming the liquid was too thick for spindle #28 to achieve an effective torque, the amount of liquid in the sample adapter was reduced from 11 mL to 6.7 mL so spindle #18 could be used to test the liquid's viscosity. The torque was higher, achieving a value ranging from 40% to 61%. Since spindle #18 achieved a higher torque for the control, this spindle was used to test the viscosity of 2 Tbsp. of oatmeal cereal in 4 oz. of infant formula. However, the viscometer errored and would not test. This means a different spindle needed to be used to test the viscometer's thickness level (AMETEK Brookfield, 2017). Spindle #28 was able to be used to test the viscosities of the other liquids analyzed for the experiment. Spindle #25Z errored when trying to measure the remaining sample sizes and spindle #18 did as well. This was a sign that the larger sample sizes were too thick or thin for spindles #18 and #25Z to measure.

Another part of this experiment that must be noted is that different measurement calculations had to be converted because of some of the tools needed to test the viscosity levels under the viscometer. For instance, one of the formulas tested required 0.5 Tbsp. of oatmeal cereal per 1 oz. of formula. Because a spoon that was capable of measuring 0.5 Tbsp. was not present in the lab, a measuring cup which measured cubic centimeters (cc) was used. The measurement 0.5 Tbsp. equals 7.5 cc. Other conversions completed included fluid oz. to mL because the viscometer sample size adapter measurements were based in mL, whereas the experiment was based on the amount of Tbsp. of oatmeal present per liquid oz. A liquid oz. is equal to 30 mL. This thesis allowed me to learn about the inconsistencies of using oatmeal cereal as a thickener and become further accustomed to the new international standard of measuring the thickness of liquids, the International Dysphagia Diet Standardisation Initiative flow test. It also allowed me to see how the thickness of liquids differed depending upon whether it was based on viscometer measurements or the International Diet Standardisation flow test. I hope that people who are providing treatment to those with pediatric dysphagia find the results of this thesis applicable to their clinical practice.

### **The Speech-Language Pathologist and the Neonatal Intensive Care Unit**

One of the roles of speech-language pathologists (SLPs) is treating swallowing disorders in infants who are in hospital Neonatal Intensive Care Units (NICUs) (American Speech-Language Hearing-Association, 2018). Many children residing in the NICU are premature and have not developed the feeding skills that are acquired in the womb. The sucking reflex starts to develop during the 32<sup>nd</sup> week of pregnancy and is not totally developed until the 36<sup>th</sup> week of pregnancy (University of Rochester Medical Center, n.d.). Because of this, many infants in the



NICU require thickened liquids to swallow effectively. Thickened liquids help many premature infants swallow because it flows slower, allowing the infant to take more time with initiating and completing their swallowing reflex (Goldfield, Smith, Buonomo, Perez, & Larson, 2013). It is important to feed the infant a formula that is not too thin or too thick. When a liquid is too thin for the infant to swallow safely, aspiration can occur (Groher & Cray, 2016). If the liquid is too thick, the infant might stop breathing during feeding or not drink enough liquid because they are fatigued from trying to swallow a liquid that requires a lot of energy to swallow (Groher & Cray, 2016). Examples of thickeners used in the NICU include fruit, commercial thickeners, and rice cereals such as oatmeal (Madhoun, Siler-Wurst, Sitaram, & Jadcheria, 2015). Infant cereal has become a popular thickener since some products of commercial thickener have been shown to cause necrotizing enterocolitis in preterm infants (Madhoun, Siler-Wurst, Sitaram, & Jadcheria, 2015; Eney, 2015).

Many speech-language pathologists base the amount of thickener they put inside a bottle upon a ratio-specific recipe (Madhoun, Siler-Wurst, Sitaram, & Jadcheria, 2015). To investigate whether this is an effective practice when feeding sizes are increased or decreased, the thickness of different sample sizes of infant formula thickened by Gerber oatmeal cereal were analyzed. As described in the "Process Analysis" section, these sample sizes were 0.5 Tbsp. of oatmeal cereal mixed in 1 oz. of infant formula, 1 Tbsp. of oatmeal cereal mixed in 2 oz. of infant formula, 2 Tbsp. of oatmeal cereal mixed in 4 oz. of infant formula, 4 Tbsp. of oatmeal cereal mixed in 8 oz. of infant formula, and 8 Tbsp. of oatmeal cereal mixed in 16 oz. of infant formula.

### Experiment Procedures

To test the viscosity of the thickened infant formula, I used two different viscosity measurement systems, the National Dysphagia Diet system (Table 1) and the International Dysphagia Diet Standardisation system (Table 2). The National Dysphagia Diet system was selected because it was, prior to the International Dysphagia Diet Standardisation system, the viscosity measurement system used by dietitians and SLPs in the United States (Sheffler, n.d.). The International Dysphagia Diet Standardisation system was used during the experiment to test the different sample sizes because it is a thickness measurement system that 21 countries are transitioning to, including the United States (American Speech-Language-Hearing Association, 2017).

The thickened formulas' viscosities were measured with the use of a Brookfield viscometer to detect the viscosity levels for the National Dysphagia Diet System. The viscometer measured the viscosity of each thickened formula every 2.5 minutes for a span of 22.5 minutes. Before placing the liquids in the small sample size adapter to be placed under the viscometer, the proper amount of liquid and oatmeal cereal were mixed in a beaker. The designated amount of the thickened formula was then poured into the sample size adapter. The amount of formula poured into the adapter was dependent upon the spindle size used for testing. (See the "Process Analysis" section for more details regarding spindle size and the amount of liquid poured into the sample size adapter.) The data used from the viscometer test was the highest and lowest viscosity levels detected by the viscometer. These viscosity measurements were then compared to the designated thickness levels and viscosity levels of the National Dysphagia Diet system (Floyd Valley Healthcare, 2017; Table 1).



The International Dysphagia Diet Standardisation flow test was used to measure the International Dysphagia Diet Standardisation thickness level of each thickened formula. When the viscometer was running a certain thickened sample, the liquid used to perform the flow test was withdrawn from the liquid that still remained in the beaker. To perform International Dysphagia Diet Standardisation flow test, one uses a syringe and withdraws 10 mL of the liquid being tested. One then fills another syringe with this 10 mL. The syringe one fills does not have a stopping device in it. To prevent liquid from flowing out of the syringe, one must place their finger over the valve. This syringe is then placed over a cup. One removes their finger from the valve and lets the liquid flow out of the syringe for 10 seconds. The amount of liquid that remains in the syringe after the 10 seconds correlates to a designated International Dysphagia Diet Standardisation level (International Dysphagia Diet Standardisation, 2016; Table 2).

### Results

The thickness and viscosity measurements did differ based upon the sample size. When evaluating thickness based upon the National Dysphagia Diet system, every lowest and highest viscosity measurement of the 0.5 Tbsp. of oatmeal cereal per 1 oz. of infant formula (both #18 and #28 spindle measurements), the 1 Tbsp. of oatmeal cereal per 2 oz. of infant formula, the 2 Tbsp. of oatmeal cereal per 4 oz. of infant formula, and the 4 Tbsp. of oatmeal cereal per 8 oz. of infant formula was considered “thin”. However, it is important to note that the viscosity of these samples gradually increased as the sample size became larger. The highest viscosity seen in the 16 oz. sample size (52 cP) was considered “nectar-thick” (Table 4).

When measuring the viscosity levels based upon the International Dysphagia Diet Standardisation drip test, a gradual increase in viscosity was also observed as the sample size increased. The smallest sample size of 1 oz. of formula had a thickness level of 0, being considered “thin”. The 2 oz. and 4 oz. sample sizes were level 1 or “slightly thick”. The 8 oz. sample size had a thickness level of 2, being considered “mildly thick” and the 16 oz. sample size was level 3 or “moderately thick” (Table 5).

### **Conclusions**

The results indicate that the practice of keeping the same ratio of oatmeal cereal per oz. of liquid when changing the amount of formula is not an effective practice when trying to maintain a consistent viscosity level. The viscometer testing shows that the viscosity generally increased the larger the sample size became. Even though many of the liquids when evaluating the thickness level via the National Dysphagia Diet system were considered “thin,” the viscosities ranged between 14 and 52 cP, a difference of 28 cP. The highest viscosity level was considered “nectar-thick”.

Similar to how the National Dysphagia Diet levels increased when sample size increased, so did the thickness seen when evaluating thickness through the International Dysphagia Diet Standardisation System. The amount of liquid remaining in the syringe increased as the sample size increased. The thickness levels ranged from “thin” to “moderately thick” and spanned four different thickness levels.

Speech-language pathologists should be cautious when changing sample sizes and maintaining the same ratio of oatmeal cereal per ounces of liquid. The thickness levels could become too thin when the sample size is decreased or too thick when the sample size is

increased. When a liquid is too thin, the infant could aspirate (Groher & Cray, 2016). When a liquid is too thick for the infant to swallow easily, they may stop breathing or only drink a small portion of the sample size because drinking the liquid is too tiresome (Groher & Cray, 2016). If possible, speech-language pathologists should test the thickness levels of new sample sizes before giving them to the infant. The most convenient method to use would probably be the International Dysphagia Diet Standardisation System flow test. It only requires two syringes and a cup if one does not want to get the liquid on anything. If the test reveals that the liquid is too thin or too thick, the recipe of oatmeal per fluid ounce or the sample size given to the infant might need to be altered.

It cannot be emphasized how much speech-language pathologists need to provide infants in the NICU with the most effective therapeutic feeding practices possible. It is the responsibility of speech-language pathologists to “minimize the risk of pulmonary complications” and “maximize the quality of life” when treating those with pediatric dysphagia (American Speech-Language-Hearing Association, n.d.). The hope is that the information in this thesis helps speech-language pathologists gain more knowledge to achieve that mission.



**Figures and Tables***Thickness Level Categorizations Based Upon Viscosity and Flow Tests*

Table 1. Viscosity Levels of Liquids According to National Dysphagia Diet (Measured Via Viscometer)		
Level #	Descriptive Adjective	Viscosity (cP)
1	Thin	0-50 cP
2	Nectar	51-350 cP
3	Honey	351-1750 cP
4	Spoon-Thick	1751 cP or more

(Chart Based Upon Data Retrieved from Floyd Valley Healthcare, 2017)

Table 2. Viscosity Levels of Liquids According to the International Dysphagia Diet Standardisation Initiative (IDDSI) (Measured via IDDSI Drip Test)		
Level #	Descriptive Adjective	Amount Remaining in Syringe
0	Thin	None
1	Slightly Thick	Between 1 mL and 4 mL
2	Mildly Thick	Between 4 mL and 8 mL
3	Moderately Thick	Between 8 mL and 10 mL
4	Extremely Thick	No liquid flows out
<b>Between Levels</b>	Between Thin and Slightly Thick	Between 0 mL and 1 mL remaining
	Between Slightly Thick and Mildly Thick	Exactly 4 mL remaining
	Between Mildly Thick and Slightly Thick	Exactly 8 mL remaining

(Chart Based Upon Data Retrieved from International Dysphagia Diet Standardisation Initiative, 2016)

*Results*

Table 3: Viscometer Viscosity Measurement of Formula/Oatmeal Cereal Sample Sizes		
Sample Size Tested (Tbsp. oatmeal per oz. of formula)	Minutes Passed when ran Under Viscometer (minutes and seconds)	Viscosity (cP) Range During 22.5 min. Viscometer Test (nearest whole cP)
0.5 Tbsp., 1 oz. (# 18 spindle)	2:15	12
	4:30	10
	6:45	9
	9:00	9
	11:15	8
	13:30	8
	15:45	8
	18:00	8
	20:15	8
	22:30	8
0.5 Tbsp., 1 oz. (# 28 spindle)	2:15	16
	4:30	15
	6:45	15
	9:00	14
	11:15	13
	13:30	12
	15:45	13
	18:00	12
	20:15	12
	22:30	12
1 Tbsp., 2 oz. (# 28 spindle)	2:15	26
	4:30	24
	6:45	24
	9:00	23
	11:15	25
	13:30	24
	15:45	24
	18:00	24
	20:15	25
	22:30	25
2 Tbsp., 4 oz. (# 28 spindle)	2:15	26
	4:30	22
	6:45	22
	9:00	22
	11:15	22
	13:30	21
	15:45	17
	18:00	16
	20:15	17
	22:30	14
4 Tbsp., 8 oz. (# 28 spindle)	2:15	37



	4:30	34
	6:45	33
	9:00	30
	11:15	28
	13:30	27
	15:45	26
	18:00	25
	20:15	24
	22:30	24
<b>8 Tbsp., 16 oz. (# 28 spindle)</b>	2:15	52
	4:30	47
	6:45	44
	9:00	43
	11:15	41
	13:30	42
	15:45	40
	18:00	39
	20:15	39
	22:30	38

Graph 1. Viscometer Viscosity Measurement

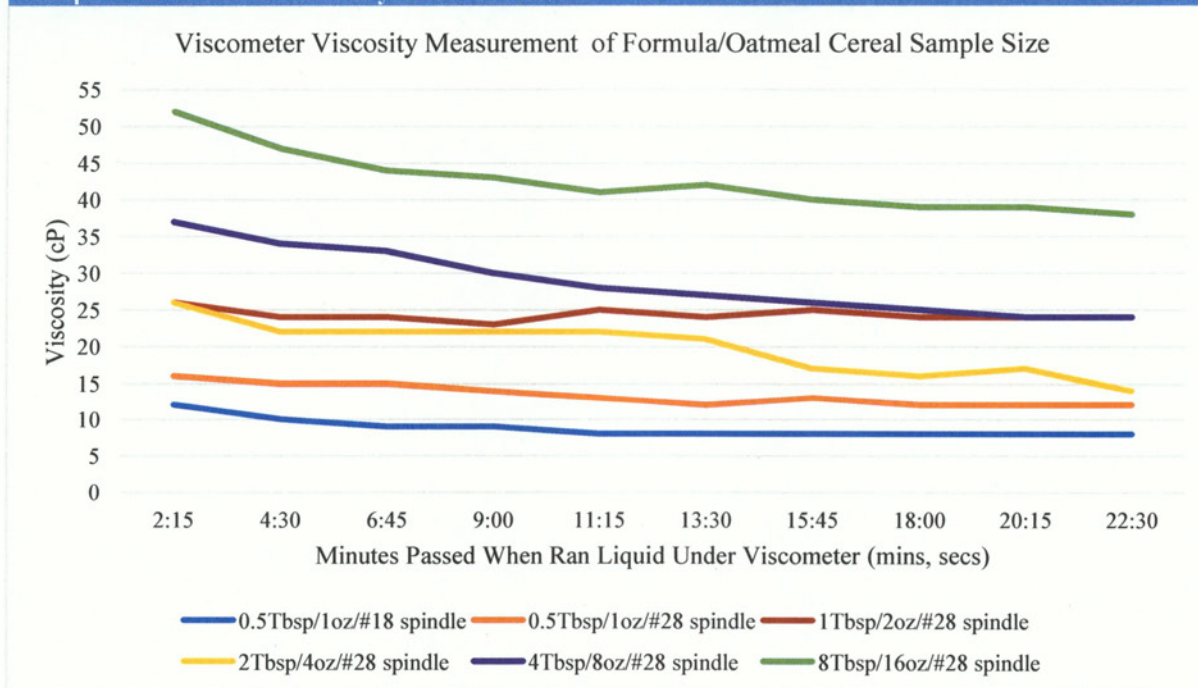




Table 4. Viscosity Levels of Sample Sizes According to National Dysphagia Diet Measurements and Viscometer Tests		
Sample Size Tested (Tbsp. oatmeal per oz. of formula)	Viscosity (cP) Range During 22.5 min. Viscometer Test (nearest whole cP)	National Dysphagia Diet Thickness Level/Description
1/2 Tbsp., 1 oz. (#18 spindle)	8 to 12	Lowest & Highest: 1/Thin
1/2 Tbsp., 1 oz. (#28 spindle)	12 to 15	Lowest & Highest: 1/Thin
1 Tbsp., 2 oz.	24 to 25	Lowest & Highest: 1/Thin
2 Tbsp., 4 oz.	14 to 26	Lowest & Highest: 1/Thin
4 Tbsp., 8 oz.	24 to 37	Lowest & Highest: 1/Thin
8 Tbsp., 16 oz.	38 to 52	Lowest: 1/Thin; Highest: 2/Nectar

Table 5. Viscosity Levels of Sample Sizes Based Upon the International Dysphagia Diet Standardization Flow Test		
Sample Size Tested (Tbsp. oatmeal per oz. of formula)	Amount of Liquid (mL) Remaining in Syringe after 10 Seconds	International Dysphagia Diet Standardization Initiative Thickness Level/Description
1/2 Tbsp., 1 oz.	0	0/Thin
1 Tbsp., 2 oz.	1.2	1/Slightly Thick
2 Tbsp., 4 oz.	1.2	1/Slightly Thick
4 Tbsp., 8 oz.	4.4	2/Mildly Thick
8 Tbsp., 16 oz.	8.6	3/Moderately Thick

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